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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 1192

DEVELOPMENT OF A COOL PROPELLANT FOR THE 3"/50 CALIBER GUN

19th Partial Report

BALLISTIC TEST OF COOL PROPELLANTS EX-7024, EX-7025, EX-7026, EX-7027, EX-7028 AND EX-7029

FINAL Report

Task Assignment NPG-Re2d-64-1-53

Copy No. 11

Classification CONFIDENTIAL SECURITY INFORMATION

CONFIDENTIAL

NPG REPORT NO. 1192

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Nineteenth Partial Report

on

Development of a Cool Propellant

for the 3"/50 Caliber Gun

- -

Final Report

on

Ballistic Test of Cool Propellants EX-7024, EX-7025,

EX-7026, EX-7027, EX-7028 and EX-7029

Proj. No.: NPG-Re2d-64-1-53
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Date: NOV 20 1953

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SECURITY INFORMATION

Ballistic Test of Cool Propellants EX-7024, EX-7025, EX-7026, EX-7027, EX-7028 and EX-7029

PART A

SYNOPSIS

1. This is the nineteenth partial report on "Development of a Cool Propellant for the 3"/50 Caliber Gun", and the final report on "Ballistic Test of Cool Propellants EX-7024 to EX-7029 Incl."

2. From the results of the subject tests, it is concluded that:

a. The ballistic uniformity of the subject propellants was satisfactory with the exception of EX-7026 which showed excessive velocity variation (±16 f/s).

b. All of the subject propellants were too slow for the 3"/50 caliber gun.

c. Slivers of unburned powder were observed in the gun barrel on all low charge rounds except with EX-7024 and EX-7027.

d. The blast effect of the subject propellants was no worse than that resulting from the master powder SPDN-9373 on single fire rounds.

e. No carbon deposition was observed in the gun barrel or cartridge case with any of the subject powders.

f. The pressure-time curves were relatively smooth with only slight steps occurring in the pressure-rise region and were smoother than those obtained with the master powder.

Ballistic Test of Cool Propellants EX-7024, EX-7025, EX-7026, EX-7027, EX-7028 and EX-7029

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Ballistic Test of Cool Propellants EX-7024, EX-7025, EX-7026, EX-7027, EX-7028 and EX-7029

PART B

INTRODUCTION

1. AUTHORITY:

The tests reported herein were conducted under Task Assignment NPG-Re2d-64-1-53, established by reference (a), and authorized by reference (b).

2. REFERENCES:

a. BUORD Conf ltr Re2d-CNB/bac NP9 Ser 42307 of 21 Jul 1952
b. BUORD Conf ltr Re2d-ERD:df S78-1 Ser 46519 of 21 Oct 1952
c. NPG Conf Report No. 770 of 9 June 1951
d. Description Sheets of Manufacture and Closed Bomb Data

3. BACKGROUND:

Reference (a) established the general task for the development of cool powders for the 3"/50 caliber gun. Reference (b) requested firings of Powder Lots EX-7024 to EX-7029 for ballistic assessment in the 3"/50 caliber gun. Reference (b) described the subject powders as cool single-base, low nitration nitrocellulose (12.07%N) with nominal flame temperatures of around 2000°F. Reference (b) further stated that the subject powders contained the following compound as coolants: EX-7024 - EX-7026 (centralite and dibutylphthalate), EX-7027 - EX-7029 (dibutylphthalate).

4. OBJECT OF TEST:

The tests reported herein were conducted to:

a. Ballistically evaluate the subject propellants in the 3"/50 caliber gun.

b. Determine the extent of carbon deposition (if any) produced by these propellants.

Ballistic Test of Cool Propellants EX-7024, EX-7025, EX-7026, EX-7027, EX-7028 and EX-7029

5. PERIOD OF TEST:

a.	Dates Project Letters:	21 Jul 1952 21 Oct 1952
b.	Date Materials Received:	4 Sep 1952
c.	Date Commenced Tests:	28 May 1953
d.	Tests Completed:	1 Jun 1953

PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEMS UNDER TEST:

The subject propellants, manufactured by E.I. duPont, are cool single-base, low nitration nitrocellulose propellants which are described in reference (d) as follows:

Actual Composition	EX-7024	EX-7025	EX-7026
Nitrocellulose (12.07%N)	93.78%	94.00%	94.11%
Centralite	3.10	2.84	2.71
Dibutylphthalate	3.12	3.16	3.18
Diphenylamine (added)	0.79	0.83	0.93
Lead Carbonate (added)	0.96	0.98	0.98
Total Volatiles	2.44	3.04	2.72

Actual Composition	EX-7027	EX-7028	EX-7029
Nitrocellulose (12.07%N)	92.80%	92.88%	92.89%
Dibutylphthlate	7.20	7.12	7.11
Diphenylamine (added)	0.97	1.01	1.10
Lead Carbonate (added)	1.07	1.04	1.00
Total Volatiles	2.19	2.72	2.24

Ballistic Test of Cool Propellants EX-7024, EX-7025, EX-7026, EX-7027, EX-7028 and EX-7029

Reference (d) also gave the following:

Sample	Grain Dimensions Length (in.)	Diam. (in.)	Av. Web (in.)	No. of Perfs.	RQ (%)	RF (%)	Flame Temp. (°K)
EX-7024	0.4490	0.1876	0.0336	7	65.3(a) 86.9(b) 136.2(c)	86.9(a) 100.7(b) 102.9(c)	2040
EX-7025	0.5430	0.2249	0.0388	7	50.2(a) 67.0(b) 105.3(c)	85.2(a) 98.4(b) 100.3(c)	2012
EX-7026	0.5680	0.2342	0.0412	7	50.5(a) 67.3(b) 104.9(c)	86.3(a) 100.0(b) 102.2(c)	2035
EX-7027	0.4490	0.1877	0.0337	7	60.8(a) 81.1(b) 126.8(c)	85.3(a) 98.8(b) 101.0(c)	1971
EX-7028	0.5450	0.2225	0.0389	7	48.9(a) 64.4(b) 101.1(c)	83.6(a) 96.6(b) 98.5(c)	1939
EX-7029	0.5610	0.2320	0.0409	7	48.5(a) 64.6(b) 100.6(c)	84.2(a) 97.6(b) 99.7(c)	1967

(a) Based on NPFB-223 as 100% at 90°F
(b) Based on EX-6705 as 100% at 90°F
(c) Based on EX-6586 as 100% at 90°F

7. PROCEDURE:

The subject propellants were fired in the 3"/50 caliber gun Mk 22 Mod 5. Muzzle velocities, maximum pressures (copper crusher), ejection-times, visual observations of flash and smoke, and qualitative determination of blast were recorded. The barrel and cartridge case were inspected after each round for evidence of carbon formation. Pressure-time records were obtained for each propellant. All rounds were assembled at PPD (Production Packing Depth).

Ballistic Test of Cool Propellants EX-7024, EX-7025, EX-7026, EX-7027, EX-7028 and EX-7029

8. RESULTS AND DISCUSSION:

The results of the subject tests are given in detail in the appendices and are summarized below:

a. Uniformity:

Date 1953	Powder	PPD (in.)	Charge (lb.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (millisec)	No. of rds.
5-28	SPDN-9373	9.9	4.05	2716±3	16.1±0.4	12±1	5
5-28	EX-7026	11.4	3.50	1765±15	5.3±0.2	19±1	2
5-28	EX-7026	3.9	6.00	2748±16	13.4±0.3	15±1	2
5-28	EX-7025	8.4	4.50	2145±9	8.0±0.2	16±1	2
5-28	EX-7025	4.5	5.75	2736±7	13.4±0.3	13±0	4
5-28	EX-7024	8.7	4.50	2451±2	10.3±0.2	15±0	2
5-28	EX-7024	7.0	5.10	2741±1	14.0±0.2	13±1	5
5-29	SPDN-9373	9.9	4.05	2704±2	15.8±0.2	13±1	5
5-29	EX-7029	6.8	5.00	2180±2	7.8±0.1	15±0	2
5-29	EX-7029	3.1	6.10	2707±4	13.0±0.1	13±0	2
5-29	EX-7028	7.6	4.75	2140±7	7.6±0.1	16±1	2
5-29	EX-7028	3.9	6.00	2731±6	13.5±0.1	13±2	4
5-29	EX-7027	8.6	4.50	2357±5	9.3±0.0	16±2	2
5-29	EX-7027	6.2	5.30	2738±1	13.6±0.1	13±1	4
6-1	EX-7024	7.0	5.05	2724±2	13.6±0.1	13±0	2
6-1	EX-7027	6.3	5.23	2687±5	12.4±0.2	14±1	2
6-1	EX-7028	4.0	5.94	2717±3	12.7±0.2	15±1	2
6-1	EX-7029	3.3	6.09	2703±8	13.1±0.2	13±0	2

b. Charge determination:
Gun data are the same as above.
Master Powder: SPDN-9373 (4.05 lb.)

Powder	Velocity (f/s)	Charge* (lb.)	Pressure (t.s.i.)	Results
EX-7024	2700	5.05	13.3	Too Slow
EX-7025	2700	5.71	12.8	Too Slow
EX-7026	2700	5.92	12.8	Too Slow
EX-7027	2700	5.23	13.1	Too Slow
EX-7028	2700	5.94	13.2	Too Slow
EX-7029	2700	6.09	13.0	Too Slow

* Determined by the matched powder method.

c. With the exception of EX-7026 which showed excessive velocity variation (±16 f/s), the ballistic uniformity of the subject propellants was satisfactory.

d. All of the subject propellants were too slow for the 3"/50 caliber gun.

e. With the exception of EX-7024 and EX-7027 (the quickest powder in each group), slivers of unburned powder were found in the gun chamber on all low charge rounds.

f. The blast effect of the subject propellants was no worse than that resulting from the master powder SPDN-9373 during single fire.

g. No carbon formation was observed in the gun barrel or cartridge case with any of the subject propellants. Reference (c) previously reported carbon deposition with single base, non-picrite propellants in the 3"/50 caliber gun. These propellants contained dinitrotoluene with rather large percentages of DBP (dibutylphthalate) 8.53 - 11.27%. Because of the data available at that time, it was thought that DBP was responsible for the carbon deposition. The subject powders, similar in flame temperature but lower in nitrate nitrogen and containing less DBP (7.11 - 7.20%), gave no evidence of carbon formation.

h. Flash and smoke obtained with each of the subject powders were normal. (Based on NH powders as 100% smoke and 100% flash.)

i. The pressure-time curves obtained with the subject powders were relatively smooth with only slight steps occurring in the pressure-rise region. The curves obtained with the master powder SPDN-9373 had large steps with a steep pressure-rise and were worse than those obtained with the subject powders.

Ballistic Test of Cool Propellants EX-7024, EX-7025, EX-7026, EX-7027, EX-7028 and EX-7029

PART D

CONCLUSIONS

9. From the results of the subject tests, it is concluded that:

a. The ballistic uniformity of the subject propellants was satisfactory with the exception of EX-7026 which showed excessive velocity variation (± 16 f/s).

b. All of the subject propellants were too slow for the 3"/50 caliber gun.

c. Slivers of unburned powder were observed in the gun barrel on all low charge rounds except with EX-7024 and EX-7027.

d. The blast effect of the subject propellants was no worse than that resulting from the master powder SPDN-9373 on single fire rounds.

e. No carbon deposition was observed in the gun barrel or cartridge case with any of the subject powders.

f. The pressure-time curves were relatively smooth with only slight steps occurring in the pressure-rise region and were smoother than those obtained with the master powder.

Ballistic Test of Cool Propellants EX-7024, EX-7025, EX-7026, EX-7027, EX-7028 and EX-7029

TABULATION OF FIRING DATA

Gun:	3"/50 Caliber, Mk 22-5, No. 20385 ESR = 349.95 Do = 3.025
Projectile:	Mk 33-0 (13.00 lb.) Epsom Salts Loaded
Cartridge Case:	Mk 9-0, Steel, Rubber Crimped
Primer:	Mk 42
Plug:	None
Wad and Spacer:	Cardboard, NGF Dwg. No. 132664 Pc Nos. 13 and 4
Lead Foil:	45 grams per round
Powder Temp:	90°F

TABULATION OF FIRING DATA (Continued)

Date: 28 May 1953

Rd. No.	Powder	PPD (in.)	Charge (lb.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (millisec)	Flash (%)	Smoke (%)
1 (a)	SPDN-9373	9.9	4.05	2710	16.0	-	100	100
2	"	"	"	2711	15.9	11	"	"
3	"	"	"	2717	16.5	"	"	"
4	"	"	"	2718	15.5	"	"	"
5	"	"	"	2715	16.0	12	"	"
6	"	"	"	2717	16.6	15	"	"
Mean of 5 rds.			4.05	2716±3	16.1±0.4	12±1		
7 (a)	EX-7026	11.4	3.50	2223	10.8	17	50	125
8 (b)	"	"	"	1750	5.1	20	"	"
9 (b)	"	"	"	1779	5.5	18	0	150
Mean of 2 rds.			3.50	1765±15	5.3±0.2	19±1		
10 (b)	EX-7026	10.0	4.00	1892	6.1	17	100	100
11 (b)	"	8.4	4.50	2073	7.6	16	"	"
12	"	3.9	6.00	2732	13.1	16	"	"
13	"	"	"	2764	13.7	14	"	"
Mean of 2 rds.			6.00	2748±16	13.4±0.3	15±1		
14 (b)	EX-7025	8.4	4.50	2154	8.2	16	100	100
15 (b)	"	"	"	2136	7.8	15	"	"
Mean of 2 rds.			4.50	2145±9	8.0±0.2	16±1		

TABULATION OF FIRING DATA (Continued)

Date: 28 May 1953 (Continued)

Rd. No.	Powder	PPD (in.)	Charge (lb.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (millisec)	Flash (%)	Smoke (%)
16 (b)	EX-7025	6.8	5.00	2357	9.5	14	100	100
17	"	4.5	5.75	2732	13.7	13	"	"
18	"	"	"	2738	13.4	12	"	"
19	"	"	"	2727	12.8	13	"	"
20	"	"	"	2748	13.8	13	"	"
Mean of 4 rds.			5.75	2736±7	13.4±0.3	13±0		
21	EX-7025	3.8	6.00	2862	15.1	12	100	100
22	EX-7024	8.7	4.50	2452	10.1	15	"	"
23	"	"	"	2449	10.4	15	"	"
Mean of 2 rds.			4.50	2451±2	10.3±0.2	15±0		
24	EX-7024	7.3	5.00	2692	13.3	14	100	100
25	"	7.0	5.10	2741	13.7	12	"	"
26	"	"	"	2739	13.8	15	"	"
27	"	"	"	2740	14.1	13	"	"
28	"	"	"	2740	14.2	14	"	"
29	"	"	"	2744	14.3	12	"	"
Mean of 5 rds.			5.10	2741±1	14.0±0.2	13±1		
30	EX-7024	6.4	5.30	2837	15.7	11		

(a) Conditioning round - not used
(b) Slivers of unburned powder in gun barrel

TABULATION OF FIRING DATA (Continued)

Date: 29 May 1953

Rd. No.	Powder	PPD (in.)	Charge (lb.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (millisec)	Flash (%)	Smoke (%)
1 (a)	SPDN-9373	9.9	4.05	2701	15.5	12	100	100
2	"	"	"	2704	15.6	14	"	"
3	"	"	"	2702	15.7	13	"	"
4	"	"	"	2700	16.0	12	"	"
5	"	"	"	2707	15.9	14	"	"
6	"	"	"	2705	15.6	12	"	"
Mean of 5 rds.			4.05	2704±2	15.8±0.2	13±1		
7 (a)	EX-7029	6.8	5.00	2233	8.4	15	100	100
8 (b)	"	"	"	2182	7.7	15	"	"
9 (b)	"	"	"	2178	7.9	15	"	"
Mean of 2 rds.			5.00	2180±2	7.8±0.1	15±0		
10 (b)	EX-7029	5.2	5.50	2413	10.1	13	100	100
11	"	3.1	6.10	2703	13.1	13	"	"
12	"	"	"	2711	12.9	13	"	"
Mean of 2 rds.			6.10	2707±4	13.0±0.1	13±0		
13 (b)	EX-7028	7.6	4.75	2146	7.5	15	100	100
14 (b)	"	"	"	2133	7.6	17	"	"
Mean of 2 rds.			4.75	2140±7	7.6±0.1	16±1		
15	EX-7028	5.4	5.50	2469	10.4	14	100	100
16	"	3.9	6.00	2730	13.6	14	"	"
17	"	"	"	2720	13.3	14	"	"
18	"	"	"	2739	13.6	12	"	"
19	"	"	"	2734	13.6	16	"	"
Mean of 4 rds.			6.00	2731±6	13.5±0.1	13±2		

TABULATION OF FIRING DATA (Continued)

Date: 29 May 1953 (Continued)

Rd. No.	Powder	PPD (in.)	Charge (lb.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (millisec)	Flash (%)	Smoke (%)
20	EX-7028	3.0	6.30	2886	15.3	13	100	100
21	EX-7027	8.6	4.50	2361	9.3	14	"	"
22	"	"	"	2352	9.3	17	"	"
Mean of 2 rds.			4.50	2357±5	9.3±0.0	16±2		
23	EX-7027	7.1	5.00	2579	11.5	13	100	100
24	"	6.2	5.30	2738	13.4	12	"	"
25	"	"	"	2736	13.7	12	"	"
26	"	"	"	2738	13.7	14	"	"
27	"	"	"	2740	13.6	14	"	"
Mean of 4 rds.			5.30	2738±1	13.6±0.1			
28	EX-7027	5.6	5.50	2845	15.5	12	100	100

(a) Conditioning round - not used
(b) Slivers of unburned powder in gun barrel

TABULATION OF FIRING DATA (Continued)

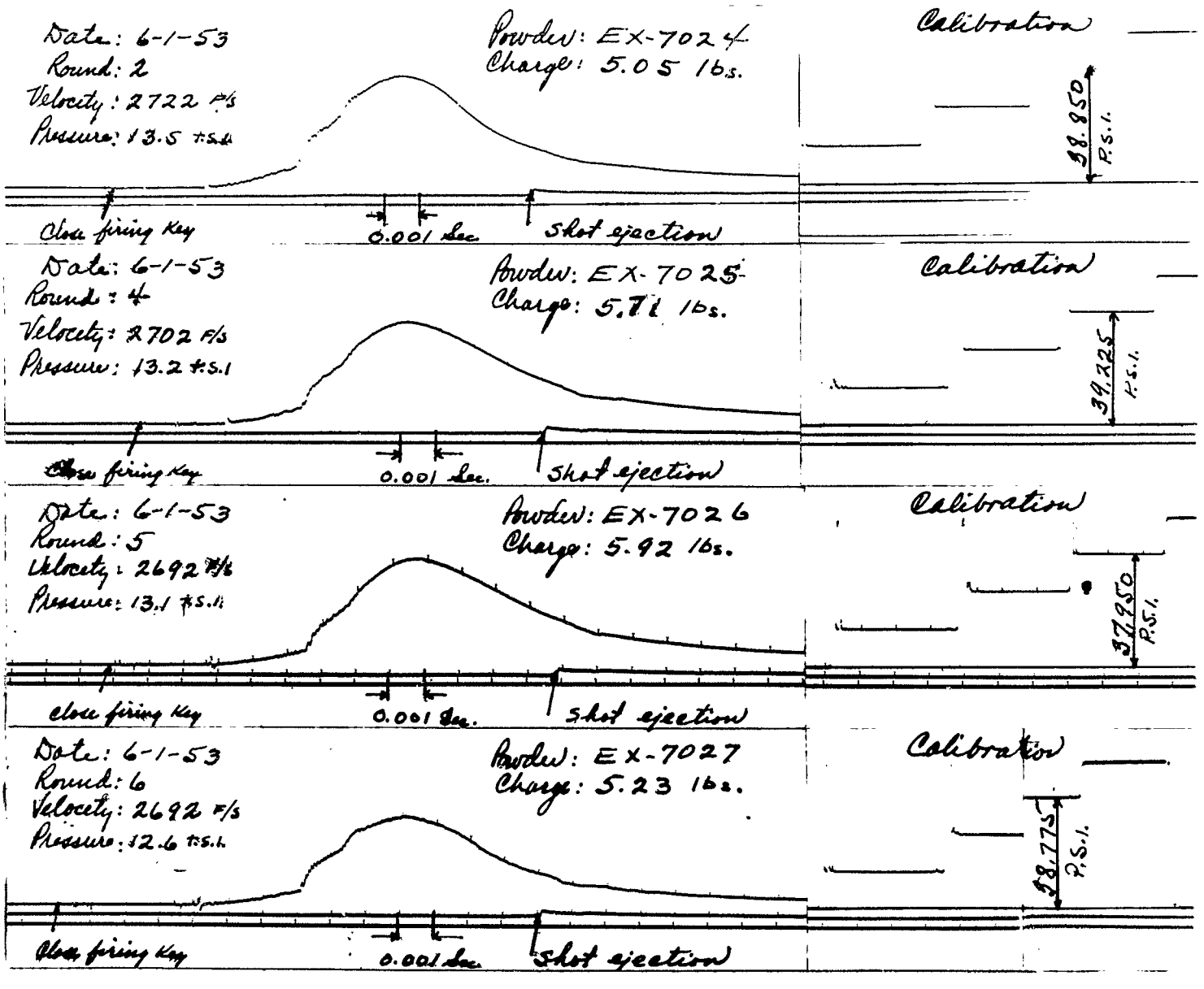
Date: 1 June 1953

Rd. No.	Powder	PPD (in.)	Charge (lb.)	Velocity (f/s)	Pressure (t.s.i.)	Ej. Time (millisec)	Flash (%)	Smoke (%)
1 (a)	EX-7024	7.1	5.05	2712	13.1	15	100	100
2	"	7.0	"	2722	13.5	13	"	"
3	"	"	"	2725	13.7	"	"	"
Mean of 2 rds.			5.05	2724±2	13.6±0.1	13±0		
4	EX-7025	4.6	5.71	2702	13.2	13	100	100
5	EX-7026	4.1	5.92	2692	13.1	-	"	"
6	EX-7027	6.3	5.23	2692	12.6	15	"	"
7	"	"	"	2682	12.2	13	"	"
Mean of 2 rds.			5.23	2687±5	12.4±0.2	14±1		
8	EX-7028	4.0	5.94	2719	12.5	16	100	100
9	"	"	"	2714	12.9	14	"	"
Mean of 2 rds.			5.94	2717±3	12.7±0.2	15±1		
10	EX-7029	3.3	6.09	2710	13.2	13	100	100
11	"	"	"	2695	12.9	13	"	"
Mean of 2 rds.			6.09	2703±8	13.1±0.2	13±0		

(a) Conditioning round - not used

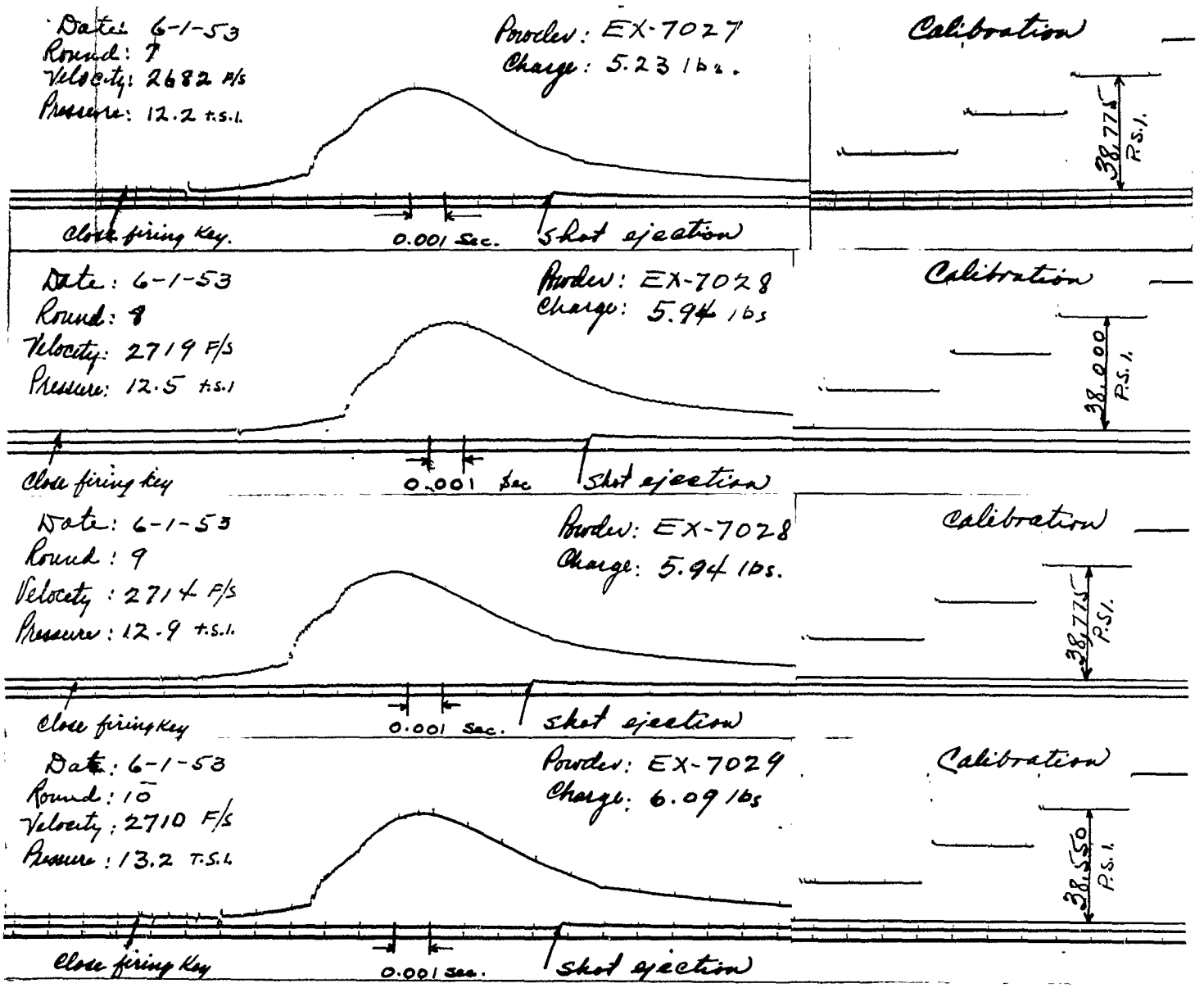
Ballistic Test of Cool Propellants EX-7024, EX-7025, EX-7026, EX-7027, EX-7028 and EX-7029

PRESSURE-TIME CURVES



Ballistic Test of Cool Propellants EX-7024, EX-7025, EX-7026, EX-7027, EX-7028 and EX-7029

PRESSURE-TIME CURVES



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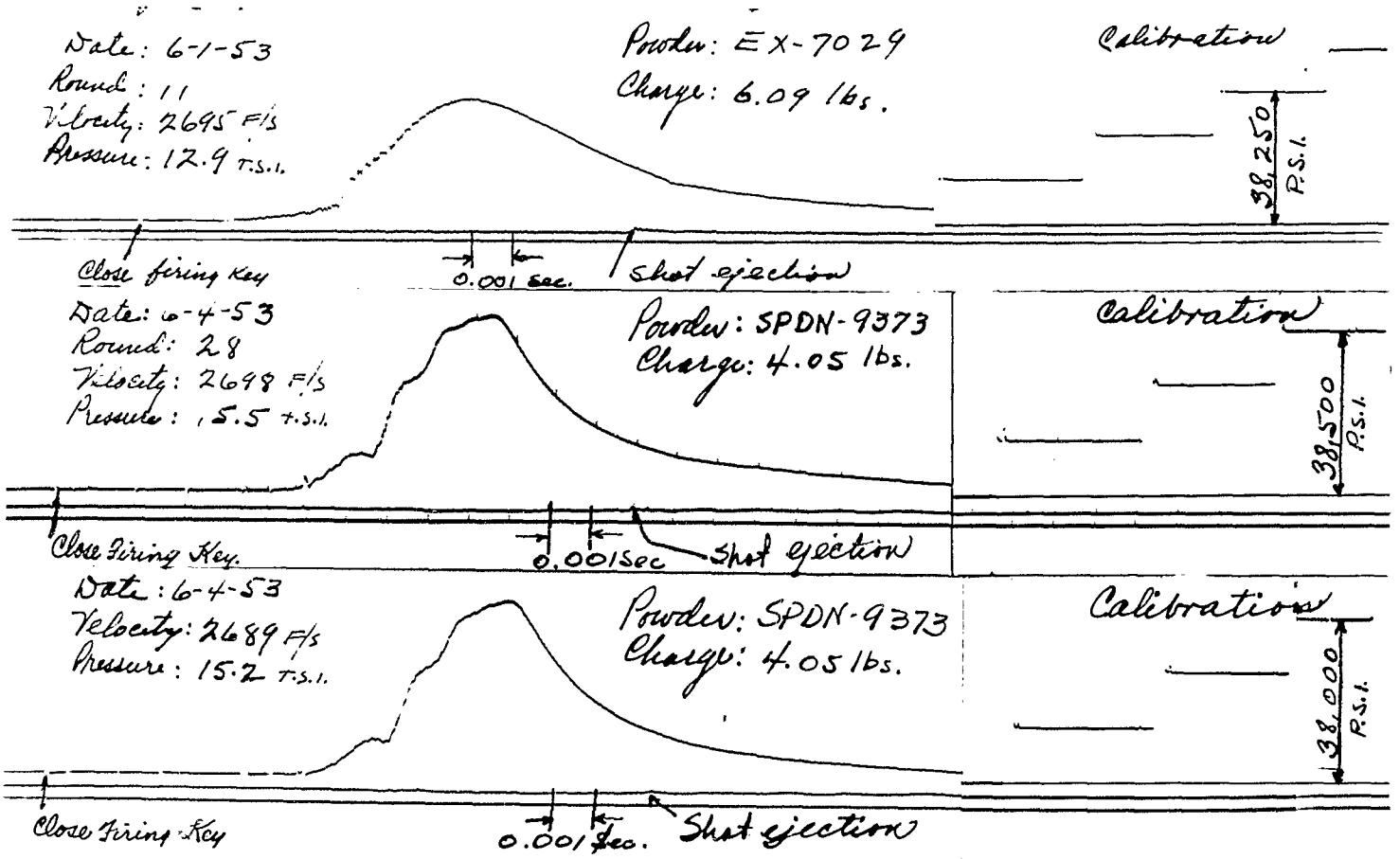
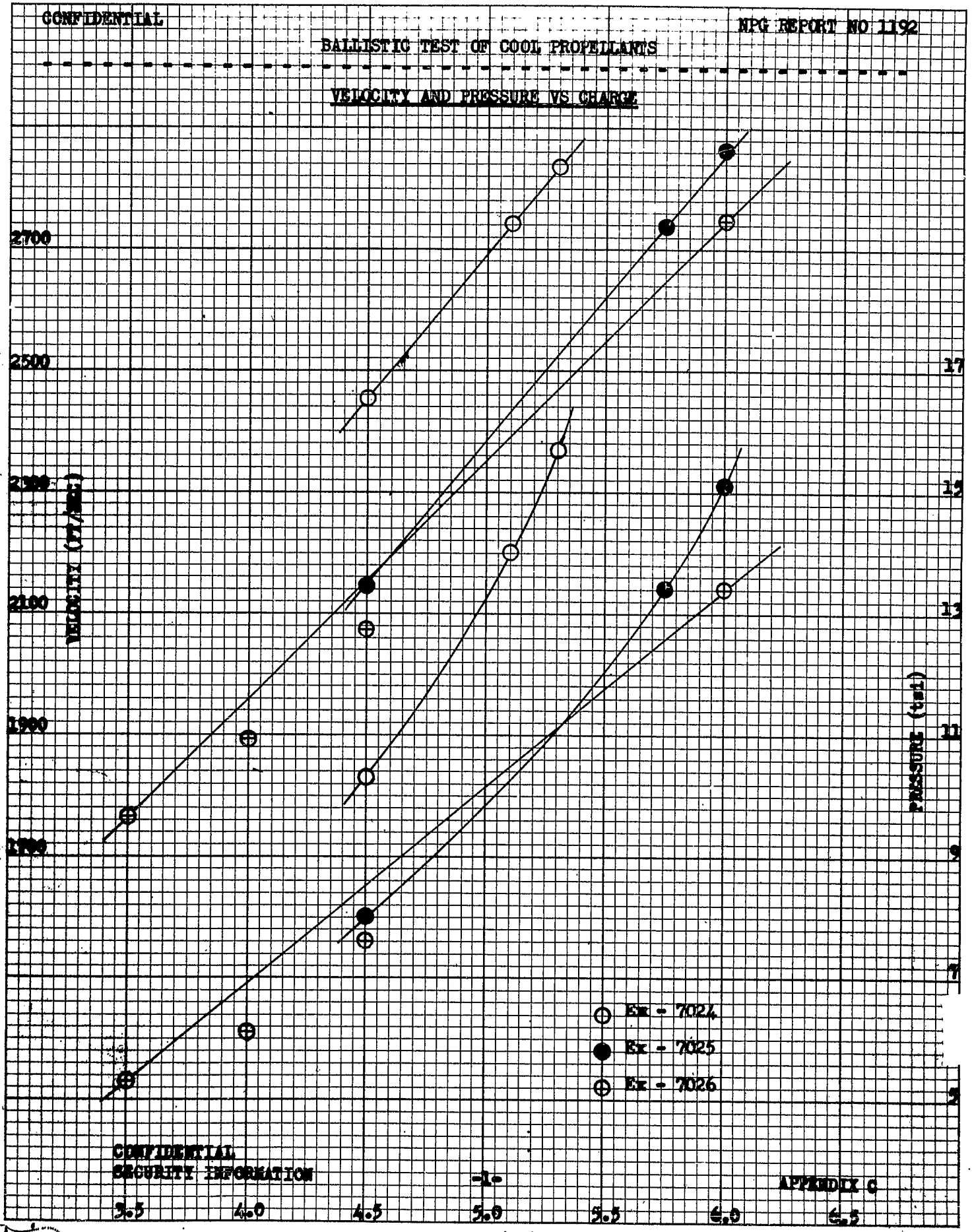
PRESSURE-TIME CURVES



BALLISTIC TEST OF COOL PROPELLANTS

VELOCITY AND PRESSURE VS CHARGE



BALLISTIC TEST OF COOL PROPELLANTS

VELOCITY AND PRESSURE VS CHARGE